THERAPEUTIC NUTRITION
WITH
TUBE FEEDING

Therapeutic Nutrition With Tube Feeding

By

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Preface

Chossat said, Inanition is the cause of death which marches abreast of and in silence with every malady in which alimentation is not in a normal state, it reaches its term sometimes sooner, sometimes later, than the disease it accompanies, and may become a principal disease where at first it had only been an epiphenomenon

Until the recent past there was no really adequate nutritional therapy for patients with malnutrition and anorexia or for patients with mechanical impediments to ingestion Tube feeding is the ideal tool for therapy in such situations When so employed it must usually be resorted to for long periods of time Until recently, upon the advent of fine, plastic feeding tubes and a practicable feeding mixture, tube feeding was not used as routine specific therapy in this manner Recent advances in tube feeding allow it to be employed in a highly efficient manner with little inconvenience to those caring for the patient and with practically no discomfiture to the patient There are however, certain intricacies involved in the proper use of tube feeding which, if ignored will mitigate against success

Thus monograph deals with the indications for, the proper application of, and the metabolic response to tube feeding in the malnourished patient The initial work was carried out in the Surgical Metabolism Section of the Homer G Phillips Hospital under the auspices of the Department of Surgery of Washington University School of Medicine with the aid of a grant from the National Institutes of Health Drs Robert Elman, Emmett J Conrad and Wilbur Hicks were early collaborators in the work

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I. Basis For Tube Feeding

That food is necessary for life is an ancient and well-known biological fact Yet in clinical medicine this principle is too often inadequately applied, to the extent that starvation in the wards of modern hospitals is not uncommon even at a time when, beset by disease, the patient can least afford the consequences of deficits due to undernutrition Though the gastrointestinal tract is intact and digestion unimpaired, it is obvious that the offering of an adequate diet is no guarantee of its acceptance Indeed, because of anorexia or of mechanical impediments to chewing or swallowing, normal enteral alimentation is often the exception rather than the rule The one obvious method for meeting this problem is the employment of satisfactory tube feeding

Healthy, well nourished individuals will tolerate a weight loss of 5 to 10% without dysfunction whereas, at the other extreme, weight losses of 35-40% are fatal (1) Severe famines have been attended by weight losses in the range of 15 to 35%

It is known from the acute starvation experiments of Benedict in the human that at the end of four weeks weight is approximately 81% of the initial body weight (2) Figure 1 plots the findings of Benedict and of the Minnesota experiments In the Minnesota experiments on semistarvation in the human, body weight was at 81% of initial in twelve weeks, and at 76% of initial in twenty-four weeks (1) Controlled experiments on more severe degrees of starvation in the albino rat indicate that death occurs at nine and one half days in acute starvation (without water deprivation) at 58 4% of initial body weight (3) whereas death occurs at one hundred twenty seven days at 36% of initial body weight in chronic protein malnutrition (pure carbohydrate diet) (4) (Figure 2) The factors involved allowing chronically undernourished and malnourished animals to give up considerably more body tissue before death than the acutely starved animal are not as yet elaborated

In the human, anorexia appears early in total starvation experiments whereas appetite is progressively accentuated in chronic starvation In the albino rat appetite does not disappear in acute or chronic starvation, or protein malnutrition until the animal is in extremis In contrast to the accentuation of appetite usually seen in simple, chronic food deprivation in the human, undernutrition and malnutrition seen in clinical medicine accom panying disease states almost invariably have associated with them degrees of anorexia dependent upon the degrees of under nutrition or malnutrition

The undernourished states associated with disease are mixed in nature, and the rate of development is relatively uncertain Usually there is a selective deficiency in protein intake and, in some situations, there is abnormal loss or sequestration of protein consequent upon the primary disease state In the rat, long-persistent chronic undernutrition results in as low total circulating plasma proteins as does prolonged feeding on a protein free diet (5)

Undernutrition associated with disease begets anorexia and the anorexia perpetuates the undernutrition The starvation-anorexia cycle is graphically illustrated in Figure 3 If the disease is limited in duration, and the undernutrition is not severe, the individual slowly eats his way back to a normal diet and, thence, to normal nutrition If the disease is prolonged, or the resultant undernutrition severe the anorexia and undernutrition become chronic Frequently, the existence of the primary disease is prolonged because of the anorexia perpetuated undernutrition In clinical undernutrition associated with anorexia, large intakes, often over prolonged periods of time are essential Figure 4 demonstrates nitrogen balance and serum albumin concentration in a markedly undernourished patient It may be seen that the serum albumin does not return to normal until fourteen weeks, and that positive nitrogen retention does not begin to decrease until after twenty five weeks These occurrences are on a hyper-caloric regimen Parenteral alimentation cannot cope with such situations Figure 5 shows nitrogen balance in a malnourished patient on no caloric intake, on parenteral alimentation on tube

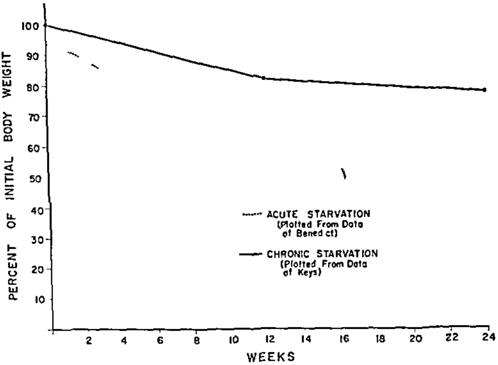

Figure 1 Weight Loss in Acute and Chronic Starvation in the Human

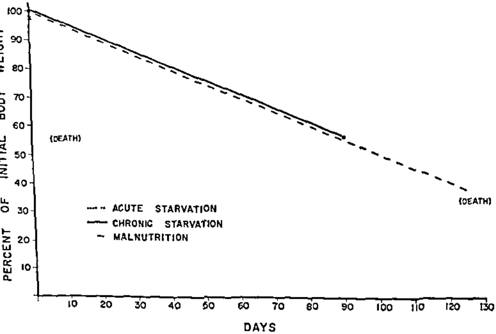

Figure 2 Weight Loss and Mortality in Acute and Chronic Starvation and Protein Malnutrition in the Rat

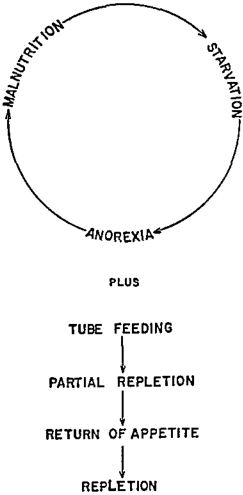

Figure 3 The Malnutrition Anorexia Cycle

feeding and, after anorexia abated on oral feeding It is seen that there is negative nitrogen balance on no intake, a mildly positive balance on parenteral alimentation and a strongly positive balance on hyper caloric tube feeding and oral intake Ordinary or special" hospital diets are to no avail because of the anorexia Furthermore, as has been stated by the Committee on Therapeutic Nutrition of the National Research Council, Dietary practices in hospitals have not kept up with recent advances in the field of therapeutic nutrition The majority of therapeutic diets outlined in hospital manuals do not supply nutrients necessary for good nutrition for acute illness convalescence and rehabilitation (6)

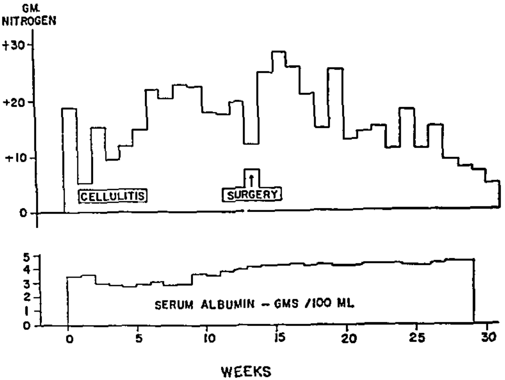

Figure 4 Nitrogen Balance and Serum Protein Regeneration on Prolonged Tube Feeding in a Severely Malnourished Patient

When undernutrition and anorexia coexist, in the wake of disease or in the course of its progress, tube feeding is by far the best and most rapid means of alimentation for nutritional rehabilitation, especially in respect to the speed of repletion In such situations tube feeding must be relatively prolonged and preferably should be administered by continuous drip This necessitates a tube that is psychologically and organically tolerable when kept in place for long periods of time, and necessitates a dietary mixture that will not clog the tube, that will not produce gastrointestinal irritation or diarrhoea, and that is relatively simple of preparation Tube feeding guarantees certainty of intake both in respect to caloric level and to a balanced intake It is the only means wherewith to give an adequate diet to the undernourished, anorectic patient

Generally speaking the applications of tube feeding find

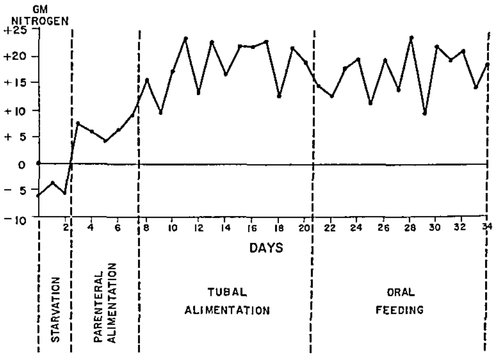

Figure 5 Nitrogen Balance During Consecutive Periods of Starvation Parenteral Alimentation Tube Feeding and Oral Feeding

their place in ingestion failures These are of two types mechanical inability to eat, and anorexia associated with undernutrition in consequence of disease or quite prolonged chronic starvation Mechanical impediments to ingestion may be local, such as in maxillofacial injuries, or systemic such as in prolonged coma of any cause In these various situations tube feeding is specific therapy

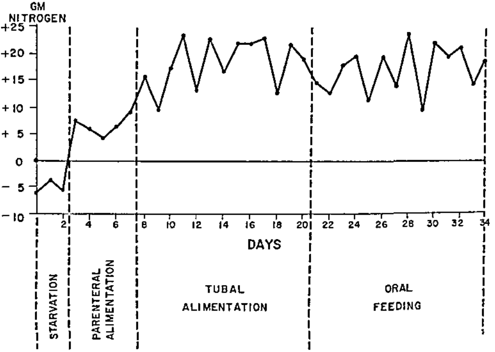

Figure 5 Nitrogen Balance During Consecutive Periods of Parenteral Alimentation Tube Feeding and Oral F

their place in ingestion failures These are of two ty ical inability to eat, and anorexia associated with in consequence of disease or quite prolonged c' Mechanical impediments to ingestion may be maxillofacial injuries, or systemic such as of any cause In these various situations therapy

II. History Of Tube Feeding

The first record of upper intestinal artificial alimentation is an account in 1598 of Capivacceus who introduced nutrient substances into the esophagus through a hollow tube to one end of which was affixed an animal bladder to contain, and with which to express, the liquid (7). Fabricius ab Aquapendente, in 1617, reported the use of a silver tube for artificial alimentation which tube was placed through the nose into the nasopharynx (8). Aquapendente used this tube in feeding patients suffering from tetanus. In 1646, Von Helmont fabricated flexible leather catheters, and early in the next century Boerhave recommended that flexible catheters be introduced into the stomach for therapeutic purposes (7). There is no record, however, that Boerhave fabricated or used such a catheter.

In the year of 1776, there appeared in the *Philosophical Transactions of the Royal Society of London* a paper by John Hunter concerned with resuscitation from drowning (9). In this paper is to be found the first mention of the introduction of substances into the stomach via a hollow catheter and a syringe.

> It will certainly prove advantageous if the same steams can be conveyed into the stomach, as that seat of universal sympathy will by these means be roused. This may be done by hollow bougie and a syringe, but this operation should be performed with all possible nimbleness, because the instrument, by continuing in the mouth, may produce sickness, an effect I should chuse to avoid. Some of the stimulating substances which are of a warm nature, and have an immediate effect, may be thrown into the stomach in a fluid state, viz., spirits of hartshorn, peppermint water, juice of horseradish, as many others also, which produce a more lasting stimulus, as balsams and turpentines, such as are found to quicken the pulse of a man in health, but the quantity must be small, as they have a tendency to produce sickness. The same steam and substances should also be thrown

up by the anus' In the year of 1790 Hunter presented a paper (10) entitled A Case of Paralysis of the Muscles of Deglutition, Cured by an Artificial Mode of Conveying Food and Medicines into the Stomach As introduction Hunter stated, Diseases *which are not mortal in themselves may often, from their sec* ondary effects, become the cause of death, but if these secondary effects are removed, the disease frequently admits of a cure, or even ceases of itself Obstructions to breathing, to the passing of the urine, to the act of swallowing, or the discharge of feces will all terminate in death, if continued for a certain length of time, whatever be the nature of the disease Difficulty in swallow*ing, the subject of the present paper may arise from a variety* of causes, since an obstruction in any part of the canal leading from the mouth to the stomach will produce that complaint The case of John S-L, about fifty years of age is described The patient had developed a hypochondriacal depression and, during its course, suddenly developed paralysis of the muscles of deglutition Hunter was called into consultation He described an orogastric tube in his possession made of spiral wire covered with gut which he used for injecting liquids into the stomach of animals He recommended that a similar tube be contrived and that when the tube was made it should be used to inject jellies, eggs beat up with a little water, sugar, and milk, or wine by way of food, and that the medicines might be mixed with it Such a tube was contrived and the patient was successfully fed as recommended for eighteen days at which time the power of swallowing was regained Baron Larrey Napoleon s surgeon general in his *memoirs of military surgery published in 1812, described the case* of a soldier who received an injury to the base of the tongue and the epiglottis in the battle of Abukir in 1801 (11) He was unable to take nourishment and on the fifth day after injury when first seen by Larrey, was in very poor condition primarily, apparently, from dehydration Larrey remarks, I happened to be very lucky to have with me an elastic rubber esophageal sound which I introduced with the necessary precautions into the pharynx and was able with this tube *to feed the patient with a small quantity of* refreshing drink which helped out very much and successively

began to feed him some excellent bouillon or soup I have repeated this procedure in front of various military surgeons at that time who have learned the procedure so that they can use it in similar cases in the future After six weeks of such feeding this particular patient was able to swallow at which time there was no longer need for the intra esophageal feeding

In 1813, Phillip Syng Physick, professor of surgery at the University of Pennsylvania, first reported the use of a flexible orogastric tube for gastric lavage (12) The occasion for this usage was a case of laudanum poisoning Physick first introduced an emetic directly into the stomach through the flexible catheter and, when this was unsuccessful, aspirated the contents of the stomach with a syringe While his report was made in 1812, he apparently had been using this method, and teaching it to his students, since 1801 Sporadic reports of gastric lavage appeared following the report of Physick In 1867, Kussmaul read a paper in Frankfurt on the use of a flexible orogastric tube in gastric decompression which popularized the use of the stomach pump From this time on, the use of the stomach tube for evacuation of gastric contents became standard in the armamentarium of medicine In 1871, Leube used the flexible orogastric tube for physiologic studies and diagnostic purposes and is credited with first using the test meal In 1874, Ewald and Oser introduced the soft rubber tube for gastric intubation

In 1879, Thomas Gallaher published a paper on the various methods of artificial alimentation in which he indicated that the major of these methods was rectal alimentation (13) In instances in which rectal disease exists and artificial alimentation is indicated, Gallaher recommends forcing food into the stomach through a double lumen esophagus tube, the purpose of the second lumen being for the escape of gases for as he stated in the use of the single tube these gases often interfere with the feeding He also mentions a method of introducing nutrient liquids into a nostril via a syringe, warning that time should be given between each syringeful for the patient to swallow and breathe Gallaher also quotes a Dr Alexander Moxey who was among the first, if not the very first, to call the attention of the

profession to the value of feeding by the nose, (passing) the food through a funnel After placing the patient in a proper position, he inserts the little end of a small Wedgwood ware funnel just within the nostril, and gently pours the food into it, in small portions (2 or 4 drachms) at a time One pint or more may be introduced at one feeding, and the operation repeated two or three times a day, or as often as may be necessary

In 1880, over one hundred years after John Hunter had first described intra-gastric feeding, a Thomas Hammond of London published a single case of feeding with the stomach pump in Lancet whereby to indicate the value of the method (14)

In 1882, Rankin published three cases of nasal alimentation One case was naso esophageal, and two were nasogastric feeding (15) He was stimulated to use nasogastric feeding by a patient who said she would starve herself to death, this, I told her, she could not do, she defied me, a quart of beef tea was soon in readiness and with the aid of four stout men, and with consider able difficulty the quart of beef tea was introduced into her stomach by means of a stomach pump, her presistency in still trying to starve herself was so great that I concluded to try some more easy, at the same time equally efficacious, means of intro ducing nutritious fluids into her stomach, a gum rubber tube 2½ feet long, and ¼ inch in diameter, was secured and a small tin funnel fitted to the one end of the tube Everything being in readiness, she was again held by four men this time, she antici pated the procedure by holding her lips and teeth firmly, expecting that I was going to introduce the tube of the stomach pump, as had been done previously But before she was aware of it, the soft gum tube well oiled was passed through one of the nostrils, and the greater part of a pint of milk was introduced through it into the stomach It was only then that she found all her efforts at keeping her lips and teeth so firmly closed did not baffle me in the effort I had undertaken The same procedure was gone through with three times a day for three days On the fourth day she concluded as she remarked to take her meals in the regular way"

The first recorded instance of orogastro enteral feeding was a

publication by Clement Jones of Pittsburgh who used the Einhorn tube for intraduodenal feeding in patients with duodenal and gastric ulcer (16). The method of feeding was by continuous drip, and there is detailed discussion of such type of feeding in Jones paper.

Until recently, while knowledge of tube feeding with the Levine nasogastric tube has been commonplace, the use of this method of artificial alimentation has been sporadic and limited. The limitations imposed have been those of the complications of the Levine tube in prolonged, continuous feeding, and the lack of a nutrient liquid acceptable to the gastrointestinal tract over prolonged periods of feeding.

III. Diet And Method Of Tube Feeding

Exactitude in the ideal caloric level of diets used for nutritional repletion, and in the relative amounts of its caloric components, can only be approximated. Beattie, Herbert and Bell, studying malnutrition victims following the liberation in World War II, found that positive nitrogen balance could be achieved if intake was above 35 Cal./kilo and 0.17 gms. N/kilo (17). They also reported that absolute nitrogen retention is apparently directly related to caloric intake provided the nitrogen intake is above the critical level of 0.17 gms./kilo. Keys *et al.*, upon refeeding semi-starved human volunteers in groups at increasing caloric and protein levels, found acceleration in body weight gain on diets containing up to 4,014 calories and 114 to 152 gm. protein. The Committee on Therapeutic Nutrition of the National Research Council recommend 3,500 or more calories per day for rehabilitation of the malnourished patient. It also recommends at least 150 gm. protein per day for sick and injured patients (6).

As has meen mentioned, many dietary formulas have been advocated for tube feeding, ranging from homogenized solid food substances, through combinations of simple dairy products combined with basic supplements, to solutions of elementary food substances. In respect to the latter, Pollack, reporting experiences with malnutrition in World War II, reported that oral protein hydrolysates and monosaccharides offered no advantages and were, in fact, deleterious as compared with skim milk powder (18). Furthermore, personal experience has been that such substances, given in adequate caloric amounts suspended in reasonable amounts of water, commonly give rise to diarrhoea. The use of homogenized food substances is unnessarily complicated, and precludes practical storage of the dietary mixture.

The ideal tube feeding mixture must be liquid, relatively sterile, remain in fine suspension, provide a complete repletion ration in reasonable quantities and, above all else, produce no

gastrointestinal irritation and not provoke diarrhoea A great many substances were used for tube feeding in our early experience Most substances tried were various natural and altered milk products, as they seemed the most practical feeding materials Most all, when given in adequate amounts, provoked diarrhoea Furthermore ordinary milk must be given in excess quantities to provide an adequate repletion ration Finally, in conjunction with Mead Johnson and Company, a form of dried milk powder, with additives, was developed that possesses all the requirements of the ideal tube feeding mixture (Table 1) Being a powder, *which is reconstituted in water when used, it is most* practical in respect to preparation, storage and transportation

The usual daily ration of the mixture used has been 900 gm (suspended in 2 liters of water) which supplies a total of 3,510 calories, 210 gm protein, minerals, iron and that amount of vitamins recommended as therapeutic levels by the Committee on Nutrition of the National Research Council The caloric distribution of the substance is 24% protein, 8% fat and 68% carbohydrate The reconstituted mixture may be made more dilute or, for intermittent feeding, more concentrated Higher caloric levels may be readily achieved by increasing the amount of the daily ration Once reconstituted in water the mixture remains in stable suspension Its viscosity, when water is added to a total volume of 2400 ml (somewhat more concentrated than normally used) is 13 centipoise at 86° F This allows it to readily flow through fine plastic catheters

*The dietary mixture and the method of feeding to be de*scribed have been employed since 1952 (19) During the first three years, two hundred forty patients were fed solely by tube under objective observation on a surgical metabolism ward The total experience represents almost 7,000 tube feeding days Only forty two of the two hundred forty were fed for less than one week Most were fed for between one and sixteen weeks, and twelve were tube fed for from three to nine months The same tube feeding mixture was used as a beverage, without the tube, in seventy six additional patients, seventeen drank the mixture for less than one week, forty five for from one to two weeks, and

TABLE 1

	%	Amount	Calories
Protein	23.5	210.0 gm	840
Carbohydrate	66.5	600.0 gm	2,400
Fat	3.5	30.0 gm	270
Minerals (ash)	2.5		
Calcium	0.7	6.3 gm	
Phosphorus	0.5	4.5 gm	
Potassium	0.7	6.3 gm	
Sodium	0.2	1.8 gm	
Chlorine	0.5	4.5 gm	
Sulfur	0.3	2.7 gm	
Magnesium	0.06	0.5 gm	
Iron (added)	0.003	0.27 gm	
Choline bitartrate		0.5 gm	
Vitamins			
Thiamine		10.0 mg	
Riboflavin		10.0 mg	
Ascorbic acid		300.0 mg	
Nicotinamide (niacinamide)		100.0 mg	
Calcium pantothenate		40.0 mg	
Pyridoxine hydrochloride		5.0 mg	
Folic acid		2.5 mg	
Cyanocobalamin (B_{12})		4.0 mg	
Moisture	2.5		
Total		900 gm	3,510

Table 1. Analysis of the Tube Feeding Mixture

fourteen from from two to four weeks. During the same period of time and since a much larger number of patients were tube fed on the open wards rather than on a surgical metabolism unit, on a practical, clinical basis.

The great majority of the patients studied fell into one of the following categories, which may be also considered as indications for tube feeding:

1. Primary malnutrition without organic cause.

2. Anorexia resulting from the effects of active acute or chronic diseases of many types including trauma, burns, various intra-abdominal diseases, cerebrovascular accidents, advanced cancer, and tuberculosis.

3. Postconvalescence malnutrition that persisted be-

cause of anorexia These were patients in whom the precipitating cause of the malnutrition had been removed but in whom the malnutrition itself induced anorexia and thus perpetuated itself and precluded spontaneous nutritional rehabilitation About one third of the patients were in this group

4 Patients with mechanical impediments to eating and swallowing due to a) maxillofacial surgery, b) interdental wiring, c) lesions of the pharynx and esophagus, and d) paralysis of swallowing muscles Patients of types "a and 'b" were given one of three feeding programs 1) a preliminary period (followed by weight loss and asthenia) of the usual routine consisting of nutritive liquids as ordinarily obtainable from the grocery store, after which tube feeding was started, 2) tube feeding used from the outset, and 3) drinking from the outset of the same 24 hour ration as was used in tube feeding

5 Patients unable to eat because of sensorial depression, i e , those semiconscious or unconscious from varying causes

6 Preoperative malnutrition in the surgical patients in whom rapid, partial, or complete nutritional rehabilitation was undertaken

7 Postoperative malnutrition in patients in whom preoperative malnutrition was either not corrected or was uncorrectable

8 Patients suffering from terminal cancer, i e , advanced spread and complete or practical invalidism

9 Undernourished patients who could eat normally but in whom more rapid rehabilitation was undertaken by hyperalimentation

Gastrointestinal tolerance to the feeding mixture used was remarkably good Of three hundred sixteen patients receiving the mixture as their sole intake (240 by tube and 76 orally) some degree of diarrhoea developed in twenty two (7%) In sixteen of the twenty two, the diarrhoea was mild and abated almost immediately upon slowing the rate of feeding In six of the twenty-

two (2%) the diarrhoea was severe and continued at all feeding levels above 1,000 calories per twenty-four hours Thus, in 5% of the patients studied there appeared mild diarrhoea that was abolished by slowing, usually only temporarily, the rate of feed ing, while in 2% of the patients (6 of 316) diarrhoea obtained of sufficient severity and persistence to warrant discontinuance of feeding or necessitate the administration of very low feeding levels

For the standard daily ration, 900 gm were used For tube feeding by continuous drip the 900 gm were suspended in 2 0 liters of water A more concentrated suspension was used for tube feeding by intermittent instillation or oral ingestion, i e, 900 gm in about 1 5 liters of water All patients were allowed to drink water at will, and all of them did However, in semi conscious and comatose patients, added water may have to be given to pre clude the danger of nitrogen retention, especially when renal concentrating function is impaired when there is an unusually large tissue protein breakdown and when the needs for water are increased In our early studies we occasionally observed pronounced azotemia with a high protein intake in such patients whenever adequate water was not given

The first forty eight hours of feeding were ordinarily on one-half ration, when feeding was by continuous drip the one half ration was distributed over the twenty four hours The most severely malnourished patients were fed a one-third ration for two days a one half ration for the next two days, and then the full ration If any tendency toward upper abdominal fullness or soft stools appeared the feeding was reduced to one half ration for another two days before full feeding was resumed

The powder was suspended by the use of a Waring Blendor or an ordinary egg beater or by hand with a spoon Each method was satisfactory When the suspension was used for continuous drip administration we were careful to ascertain that no lumps remained after stirring When the powder was suspended by use of the Waring Blendor it was necessary to wait a few hours to allow air bubbles to escape before using In storing and handling the powder and in preparing the suspension only the ordinary

sanitary precautions as practiced in the home kitchen have been observed. No more than a twenty-four ration was suspended at one time and, once suspended, the liquid was stored in a refrigerator but was shaken thoroughly before portions were removed. For continuous drip no more than 300 ml. was placed in the drip flask at one time. Outpatients were furnished three to seven days rations in powder form and instructed in the method of suspension. Many patients were able to continue their work by carrying the midday aliquot with them in a thermos container.

Three methods of feeding were used: 1) continuous twenty-four hour drip, 2) intermittent administration in from four to six aliquots per twenty-four hours, and 3) a combination of the two methods. These were not used in patients who were able to drink the twenty four hour ration yet who were unable to eat solid food. The initial feeding of all anorectic and malnourished patients was done with the continuous drip method, intermittent feeding was substituted after one to three weeks. The longer periods of continuous feeding were observed in the more severely malnourished patients. Tubal alimentation was discontinued when a mechanical impediment to eating disappeared, when acute illness subsided and the patient recovered his appetite, when anorexia disappeared, or when surgery was undertaken in preoperatively malnourished patients.

Fine polyvinyl or polyethylene tubing may be used as the feeding tube. In the initial studies a polyvinyl tube of 2.5 mm. external diameter was used. This is known in the insulating industry as number 13 clear transflex polyvinyl tubing. This, or comparable size polyethylene tubing, may be purchased in long rolls and cut in desired lengths. The tip needs no special preparation and it is preferable not to have side holes as this weakens the small tube and may permit it to break inasmuch as the terminal portion may become stiff if the tube is left in place for long periods of time. For continuous feeding it is preferable to leave a considerable length of tubing outside of the nares in order that the patient might have appreciable flexibility of movement. When intermittent feeding, by injection through the tubing with a syringe, is employed it is preferable to leave only a very short

length protruding from the nostril This makes the tubing inconspicuous and it is worn comfortably The shaft of a number 15 gauge hypodermic needle fits snugly in the lumen of this tubing and makes a water-tight seal

For continuous drip the hub of the needle is connected to an adapter at the distal end of an ordinary rubber tubing leading from an open type infusion flask A glass drip meter is interposed in the rubber tubing so that drops can be seen and the rate of flow regulated by a pinch clamp The same feeding tube has been left in place up to four months without clogging or producing irritation However, the rubber connections, drip meter and flask must be replaced or cleaned every twenty four hours For intermittent feeding the aliquot is injected into the tubing via a number 15 gauge needle attached to a 50 ml syringe Intermittent feedings should be followed by a small amount of water to clean the tube and prevent fermentation of the mixture that would otherwise occupy its lumen

Intubation with the fine plastic tube is relatively easy It differs from intubation with the rubber tube (or larger plastic tube) in that it cannot be as greatly aided in its passage by pushing and in that it frequently takes a longer period of time for passage The tube may be aided somewhat in its passage by chilling in ice water which gives it additional body It is so light that, with time, it is swallowed into the stomach This is true even in semicomatose and comatose patients as long as the swallowing reflex remains

No instances of aspiration pneumonia or esophageal ulceration have been noted in the initial study series or since No tube has become occluded during the feeding periods some of which were quite prolonged Psychological acceptance is excellent, rarely does a patient give a specific physical complaint in respect to the indwelling tube Patients fed by continuous drip if fed properly at an even rate do not complain of excess fullness while patients fed intermittently experience normal satiety

IV. The Time Factor In Tube Feeding

It has been conclusively demonstrated by Rose, Raines and Johnson (20) and by Elman (21) that all of the essential amino acids must be supplied simultaneously for tissue protein fabrication to take place Cox and Mueller (22) demonstrated that the rate of regeneration of serum albumin may depend upon the rate of protein hydrolysis or upon the rate of absorption and utilization of amino acids Geiger (23) has shown that nitrogen retention and growth response in rats are higher when the protein and nonprotein moieties of the diet are presented simultaneously than when they are given separately at several hours intervals Based on these various time factors, Elliott *et al* (24) assumed that oral or intravenous intermittent feeding would not constitute an adequate method of feeding sick patients, and that continuous presentation of food would, therefore, be preferable

Intermittent feeding via the tube is much more convenient than feeding by continuous drip As soon as repletion is sufficiently advanced so as to allow gastrointestinal acceptance, intermittent feeding, if there is any residual degree of anorexia, should replace the continuous drip This being desirable, studies were made of the influence on nitrogen balance and weight gain of isocaloric diets given by continuous twenty four hour drip and by intermittent, fractional injection through the same tube at various, arbitrarily chosen intervals

Eleven patients, presenting varying degrees of malnutrition with anorexia and with varying diseases, were studied None presented extraneous avenues of nitrogen loss or azotemia Each experiment in these patients consisted of three consecutive periods of ten days each The daily ration for each patient was identical in all periods In the first and third periods feeding was given by twenty four hour continuous drip Feedings in the second period were given in equally divided aliquots of the twenty-four hour ration at intervals as follows three patients were fed

length protruding from the nostril This makes the tubing inconspicuous and it is worn comfortably The shaft of a number 15 gauge hypodermic needle fits snugly in the lumen of this tubing and makes a water-tight seal

For continuous drip the hub of the needle is connected to an adapter at the distal end of an ordinary rubber tubing leading from an open type infusion flask A glass drip meter is interposed in the rubber tubing so that drops can be seen and the rate of flow regulated by a pinch clamp The same feeding tube has been left in place up to four months without clogging or producing irritation However, the rubber connections, drip meter and flask must be replaced or cleaned every twenty four hours For intermittent feeding the aliquot is injected into the tubing via a number 15 gauge needle attached to a 50 ml syringe Intermittent feedings should be followed by a small amount of water to clean the tube and prevent fermentation of the mixture that would otherwise occupy its lumen

Intubation with the fine plastic tube is relatively easy It differs from intubation with the rubber tube (or larger plastic tube) in that it cannot be as greatly aided in its passage by pushing and in that it frequently takes a longer period of time for passage The tube may be aided somewhat in its passage by chilling in ice water which gives it additional body It is so light that with time, it is swallowed into the stomach This is true even in semicomatose and comatose patients as long as the swallowing reflex remains

No instances of aspiration pneumonia or esophageal ulceration have been noted in the initial study series or since No tube has become occluded during the feeding periods, some of which were quite prolonged Psychological acceptance is excellent, rarely does a patient give a specific physical complaint in respect to the indwelling tube Patients fed by continuous drip if fed properly at an even rate do not complain of excess fullness while patients fed intermittently experience normal satiety

TABLE 2

TIMING OF INTERMITTENT FEEDINGS DURING SECOND PERIOD	PATIENT	PERCENT BODY WEIGHT LOSS	AVERAGE DAILY CALORIC INTAKE	AVERAGE DAILY N INTAKE	AVERAGE DAILY N BALANCE (GMS) DURING CONSECUTIVE 10 DAY PERIODS		
					1 CONTINUOUS 24 HOUR DRIP	2 INTERMIT TENT FEEDING	3 CONTINUOUS 24 HOUR DRIP
EVERY 4 HOURS DURING 24 HOURS (6 FRACTIONS)	N Y	11	3,500	33 6	+24 2	+25 5	+24 3
	G S	31	3,140	30 2	+10 9	+12 4	+12 7
	N B	21	3 290	31 7	+20 9	+15 1	+13 3
EVERY 6 HOURS DURING 24 HOURS (4 FRACTIONS)	G S	5 5	4,500	43 2	+33 0	+33 2	+32 8
	F C	0	3,500	33 6	+21 3	+22 7	+22 7
EVERY 3 HOURS DURING 12 HOURS (4 FRACTIONS)	J C	11 5	3 500	33 6	+27 5	+27 4	+25 6
	M N	22 5	3,500	33 6	+24 7	+24 2	+24 8
	C S	18	3 500	33 6	+25 3	+24 4	+27 4
CONTINUOUS DRIP DURING 14 HOURS OF EACH 24 HOURS	P B	17	3,500	33 6	+19 6	+18 0	+22 0
	F H	28	3,500	33 6	+19 8	+22 1	+20 3

Table 2 Influence on Nitrogen Balance of Administering the Total Ration in Varying Intervals of Intermittency as Compared to Administration by Continuous 24 Hour Drip at a Constant Rate

every three hours during twenty four hours, three patients were fed every four hours during twenty-four hours, three patients were fed every six hours during twenty four hours, and two patients were fed the total diet by continuous drip during fourteen consecutive hours of the twenty four hours

Table 2 presents the average daily nitrogen balance during the consecutive periods in each of the patients studied No significant difference is seen in the various periods Nitrogen retention during the periods of intermittent feeding was as efficient in all experiments as the preceding and following periods of continuous twenty four hour feeding Also, no difference was noted in the trend of weight gain between the three periods in any of the patients studied Figures 6 and 7 graphically show two additional experiments

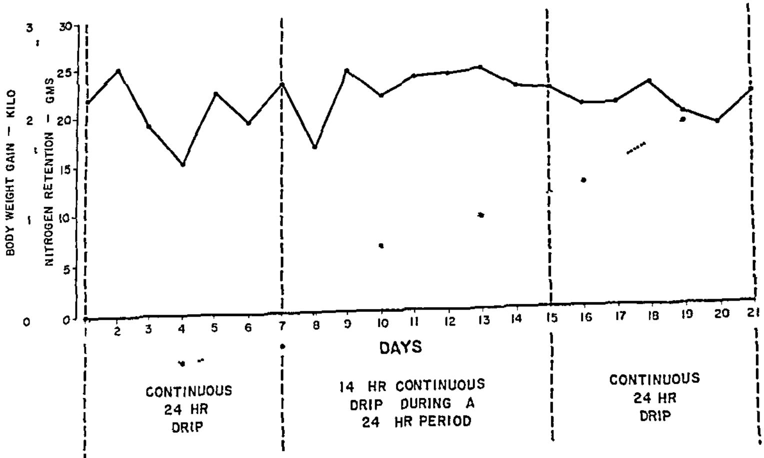

Figure 7 Weight Gain and Nitrogen Balance on Continuous and on Intermittent Tube Feeding

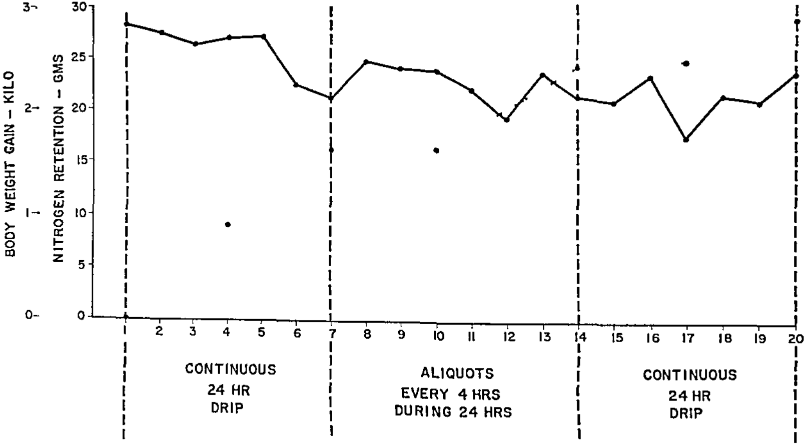

Figure 6 Weight Gain and Nitrogen Balance on Continuous and on Intermittent Tube Feeding

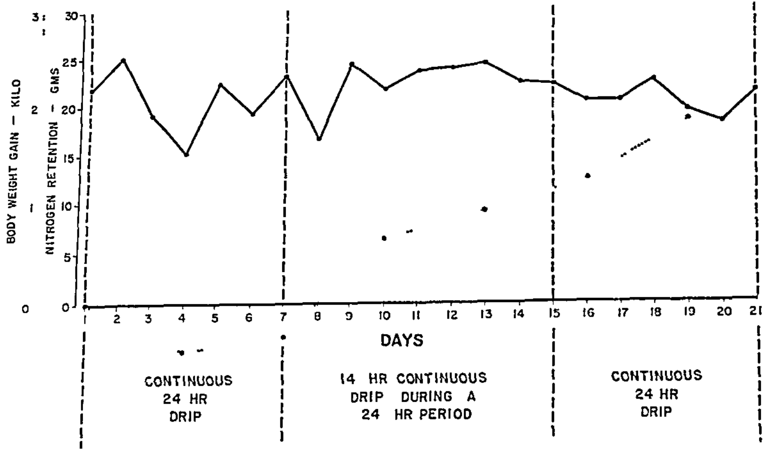

Figure 7 Weight Gain and Nitrogen Balance on Continuous and on Intermittent Tube Feeding

V. Response Of Starved Patients To Tube Feeding

The general response of malnourished patients to tube feeding is quite dramatic Within one to three weeks after the onset of tube feeding severely malnourished, bedfast patients begin regaining strength and become ambulatory This point is often reached before there is appreciable weight gain

Weight gain has been observed in all patients fed a significant length of time Very frequently a transient loss in weight preceeds the weight gain This undoubtedly represents a loss of occult edema which, in the early days of feeding, is a more prominent weight factor than fabrication of body tissue In the Minnesota experiments on starved volunteers, Keys reported that twenty one of thirty two showed an early weight loss on re feeding (1)

Appetite returns in nearly all patients after one to four weeks of tube feeding The time for appetite return is roughly proportional to the degree and duration of the malnutrition as may be seen in Table 3 As appetite returns, many patients request permission to eat around the tube and when allowed, do so in addition to an intake by tube of 3 500 calories In many patients studied the spontaneous caloric intake was calculated from the meal trays and found to remain high At some point between the return of strength and the return of appetite aliquot feedings are tolerated and may be substituted for continuous drip

Metabolic studies including nitrogen and water balance and blood chemical changes were made in 25% of two hundred forty patients observed on a surgical metabolism division None of the patients studied failed to show a positive nitrogen balance after the institution of tube feeding Most of these patients remained in positive balance for long periods of time due to the degree of malnutrition present

In Figure 8 there is shown nitrogen balance and weight gain in a sixty four year old man who had become asthenic and anorectic and had finally become bedfast several months after successful surgical correction of a prolonged partial intestinal obstruction He had lost 18 kilo in weight After he was fed by tube he gained weight steadily, and a positive nitrogen balance was noted The concentration of serum albumin and the hemato crit level also increased without blood transfusions He was fed the standard ration for thirty days Figure 9 shows the body weight curve in a two year old child who had sustained a head injury The child had refused to eat and had a relatively marked drop in body weight The child became critically ill in spite of parenteral alimentation His condition improved when tube feeding was instituted at the beginning of the third hospital week Within one week the general condition was so much improved that a subdural hematoma could be successfully evacuated Con-

TABLE 3

PATIENT	AGE	PERCENT BODY WEIGHT LOSS	DURATION ANOREXIA (DAYS)	RETURN OF APPETITE (DAYS)	NITROGEN RETAINED (GMS)	WEIGHT GAIN (KILO)
L C	71	35	280	21	204 2	2 2
V C	37	8	28	7	139 4	2 4
E H	68	25	42	9	192 8	1 1
M S	39	31	140	9	124 6	2 9
L B	52	26	140	9	226 5	2 7
E H	70	59	280	37	700 2	3 6
N B	46	21	35	19	339 1	3 4
J O	59	34	140	15	386 9	3 0
N Y	47	34	196	7	104 9	0 3
G S	47	31	56	21	247 3	2 8
M J	38	34	84	21	295 4	0
W B	27	19	84	12	145 9	0 7
W S	41	27	56	9	200 8	2 9
M P	28	?	511	56	700 0	?
S S	64	32	?	18	308 0	5 1
M S	46	?	175	15	273 5	?
J B	51	25	196	15	197 9	4 0
B S	32	33	56	8	167 8	3 5

Table 3 Duration of Anorexia and Degree of Repletion Necessary for Regaining of Appetite in Malnourished Patients on Tube Feeding

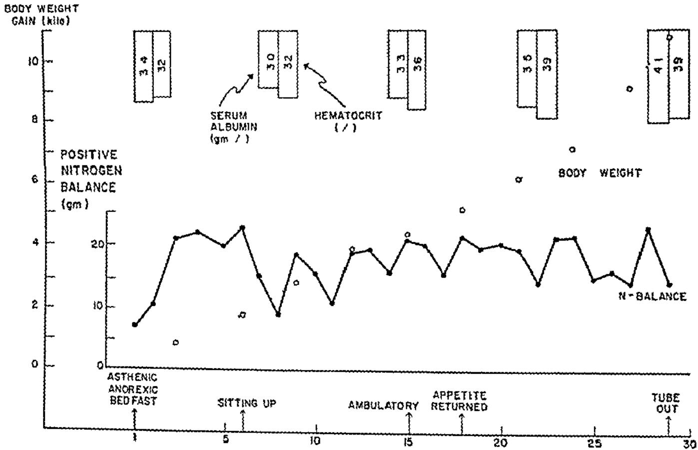

Figure 8 Weight Curve and Nitrogen Balance in a Patient with Prolonged Postoperative Malnutrition while on Tube Feeding

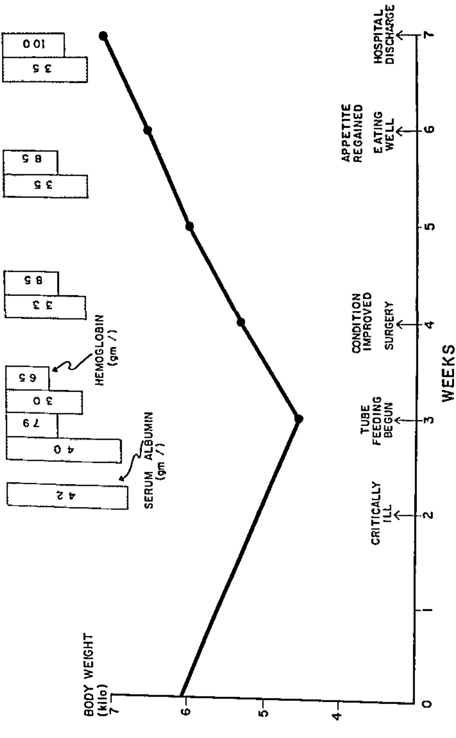

Figure 9 Weight Curve in a Child with Acute Preoperative Undernutrition Fed by Tube

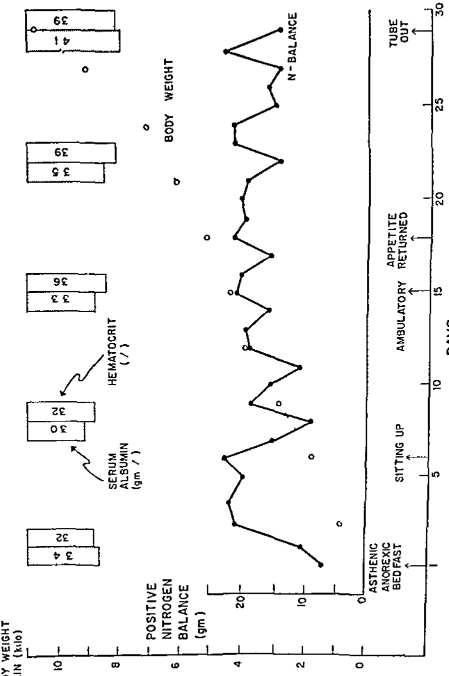

Figure 8 Weight Curve and Nitrogen Balance in a Patient with Prolonged Postoperative Malnutrition while on Tube Feeding

VI. Tube Feeding In Advanced Cancer

Sixty-four of the three hundred sixteen patients studied on the surgical metabolism ward were patients with advanced cancer (26) Investigation of this group of patients was designed to study the possibilities of nutritional rehabilitation of the cachectic patient with advanced cancer as compared with the non cancer, equally malnourished control It was particularly intended to determine whether the cachexia of cancer is a primary accompaniment of the disease or a secondary result of anorexia, and also whether clinically significant palliation might be achieved by attempts at nutritional rehabilitation of the cachectic cancer patient

The sixty four terminal cancer patients selected for the present study all showed evidence of advanced spread (Table 5) All applicable forms of therapy had either been used or considered to be contraindicated All of the patients selected had been hospitalized for terminal, nonspecific care and thus were complete, or nearly complete, invalids The majority were bedfast, and all were asthenic and cachectic

TABLE 5

SITE OF CANCER	NO OF PATIENTS	DAYS OF TUBE FEEDING	
		RANGE	AVERAGE
Cervix	26	6–49	18
Large intestine	10	4–28	15
Stomach	6	12–27	18
Oropharynx	6	5–56	26
Tongue	4	14–28	22
Pancreas	3	9–49	27
Breast	3	4–21	14
Other	6	6–63	28
Total	64	4–63	20

Table 5 Tube Feeding in Patients with Advanced Cancer

tinued general improvement and weight gain followed, and two weeks later the tube was removed The child ate well and was discharged from the hospital one week later These two patients are representative of the typical response to tube feeding

Most of the patients studied showed an increase in serum albumin and hemoglobin concentrations (Table 4) The increase in these components was usually preceeded by a transient de crease, representing the reflection of re hydration As has been reported previously by Whipple s group (25), hemoglobin re generation took precedence over serum albumin regeneration

TABLE 4

PATIENT	AGE	PERCENT BODY WEIGHT LOSS	DAYS TUBE FED	TOTAL NITROGEN RETAINED (GM)	WEIGHT GAIN (KILO)	SERUM ALBUMIN REGENERATION GMS/100 ML	HEMOGLOBIN REGENERATION GMS/100 ML
L C	71	35	49	604 0	6 0	0 5	2 4
J O	59	34	49	1016 1	7 8	1 1	3 0
B C	56	29	30	904 0	0 9	1 6	1 5
G S	47	31	16	190 7	2 8	1 0	3 7
B G	56	30	17	307 3	2 8	–0 6	2 3
N B	46	21	30	444 5	4 5	1 1	3 0
E H	70	59	37	692 6	3 6	0 3	1 6
L B	52	28	27	619 2	3 0	–0 5	2 0
V C	37	8	7	139 4	2 7	0 4	0 5
E H	68	25	18	343 5	1 3	0 4	0
O W	34	23	21	505 7	2 5	0 5	0
N Y	47	34	9	142 7	2 8	0	0 7
F C	53	?	26	582 0	1 4	0	1 0
M W	53	22	25	612 7	0 8	0	0 5
W B	27	19	22	215 4	4 3	0 8	3 0
W S	41	27	33	618 2	6 0	1 0	1 7
S S	64	32	29	507 9	10 7	1 1	0
G R	54	0	14	241 1	5 4	0 7	1 0
C S	43	18	30	780 3	2 1	0 4	1 0
B S	32	33	12	303 4	8 7	0 2	1 0
M S	46	?	23	432 1	?	1 1	3 0

Table 4 Serum Albumin and Hemoglobin Regeneration and Nitrogen Retention in Malnourished Patients on Tube Feeding

TABLE 7

PATIENT AGE SEX	PRIMARY SITE	TOTAL % BODY WT LOSS FROM PATIENT'S PREVIOUS AV WT	DURATION ANOREXIA DAYS	DURATION INVALIDISM DAYS	PERIOD INTUBATION DAYS	APPETITE RETURNED DAYS	AMBULATORY ACTIVE DAYS	EVENTUALITY
L C, 71, F	Cervix	35	280	56	30	21	30	Discharged, eating well employed 6 mo thereafter
V C, 37, F	Cervix	8	28	21	7	7	7	Discharged, eating well, active
E H, 68, M	Stomach	25	84	14	14	14	7	Discharged, eating well, active
E M 70, M	Pharynx	59	280	56	37	37	24	Activity and normal appetite retained until 1 wk. prior to death 3 mo later
N B, 46, F	Cervix	21	105	14	30	30	12	Discharged actively engaged in housework, eating well
J O, 59 M	Pancreas	34	140	42	14	14	14	Discharged, eating well active
N Y, 47, M	Pancreas	34	196	175	15	15	15	Discharged eating well active
G S, 47, F	Breast	31	84	42	26	26	20	Discharged, eating well, active
O W, 34, F	Cervix	23	210	56	21	21	21	Discharged, eating well, active
B C, 56, F	Cervix	29	84	21	26	26	10	Became ambulatory Able to return home

Table 7 Rehabilitation by Tube Feeding of Completely Invalided Patients with Advanced Cancer

TABLE 6

CASE	AGE	CANCER	% BODY WEIGHT LOSS	DURATION OF ANOREXIA, DAYS	RETURN OF APPETITE, DAYS	NITROGEN RETAINED GM	WEIGHT GAIN KG
1	71	+	35	280	21	204 2	2 2
2	37	+	8	28	7	139 4	2 4
3	68	+	25	42	9	192 8	1 1
4	39	+	31	140	9	124 6	2 9
5	52	+	26	140	9	226 5	2 7
6	70	+	59	280	37	700 2	3 6
7	46	+	21	35	19	339 1	3 4
8	59	+	34	140	15	386 9	3 0
9	47	+	34	196	7	104 9	0 3
10	47	+	31	56	21	247 3	2 8
11	38	—	34	84	21	295 3	0
12	27	—	19	84	12	145 9	0 7
13	41	—	27	56	9	200 8	2 9
14	28	—	Unknown	511	56	700 0	Unknown
15	64	—	32	Unknown	18	308 0	5 1
16	46	—	Unknown	175	15	273 5	Unknown
17	51	—	25	196	15	197 9	4 0
18	32	—	33	56	8	167 8	3 5

Table 6 Relief of Anorexia During Nutritional Rehabilitation in Cancerous and Noncancerous Cachexia

TABLE 8

PATIENT	CANCER	TOTAL % BODY WT LOSS FROM PATIENT S PREVIOUS AV WT	N RETAINED / N INTAKE (9 DAYS)	TH WT GAIN / ACT WT GAIN	DAYS ON TUBE	N RETAINED AV GM/DAY	WT GAIN AV KG/DAY
V C	+	8	0 59	1 5	7	19 8	0 34
E M	+	25	0 64	5 0	9	21 4	0 12
M S	+	31	0 41	1 3	9	13 6	0 32
E H	+	59	0 58	2 0	37	18 9	0 10
N B	+	21	0 69	2 8	19	17 8	0 17
J O	+	34	0 81	3 2	15	25 8	0 20
N Y	+	34	0 51	1 5	7	15 0	0 07
G S	+	8	0 42	1 1	21	11 7	0 13
M W	+	22	0 73	2 3	–	–	–
O W	+	23	0 72	6 1	–	–	–
L C	+	–	–	–	21	9 7	0 10
L B	+	–	–	–	9	25 1	0 30
W B	–	19	0 40	0 9	12	12 1	0 06
W S	–	27	0 66	2 1	9	11 2	0 32
S S	–	32	0 55	1 5	18	17 1	0.28
G R	–	0	0 53	2 3	–	–	–
J B	–	25	0 46	1 3	15	13 2	0 26
B S	–	8	0 60	1 3	8	21 0	0 43
C S	–	18	0 76	1 3	–	–	–

Table 8 Nitrogen Balance and Body Weight Gain in Cancer Cahexia During Nutritional Rehabilitation.

None of the patients would eat much of the regular hospital diet, and all efforts at persuasion and special selection of diets were unsuccessful and finally abandoned in favor of tube feeding. In no patient in this series did the tumor involve the gastrointestinal tract, and none presented any indication for intravenous feeding. In no case was there evidence of abnormal fluid, blood or protein loss from ulcer or fistula.

All patients were weighed initially and every three to seven days thereafter. The duration of asthenia and anorexia and the time of their disappearance following initiation of tube feeding were recorded. The number and consistency of stools were recorded daily. Metabolic studies, including determination of nitrogen balance and the concentrations of hemoglobin and fractional plasma proteins, were made in about one fourth of the total number of patients studied.

Anorexia disappeared in nearly all of the treated cancer patients in this series (Table 6). The only exceptions were a few in whom feeding was started within only a few weeks of the fatal outcome. Return of appetite was shown by the patient's desire to eat around the tube, followed by the act of doing so if permitted (in spite of a 3,500 calorie intake), or by ingestion of a diet of isocaloric value or better as calculated from a tray following removal of the tube. No difference in response between cancer and non cancer patients was noted. Return of appetite usually occurred between one and three weeks after beginning tube feeding. The period necessary for return of appetite was roughly proportional to the degree and duration of malnutrition.

While most of the advanced cancer patients were actually near death when admitted, as would be expected in a city institution, many who were thought to be terminal and had been bedfast because of cachexia were rehabilitated by virtue of tube feeding for a period of many months prior to their eventual demise (Table 7).

Practically all cancer patients who were tube fed showed some increase in general strength and a majority became at least partially ambulatory, more comfortable and able to care

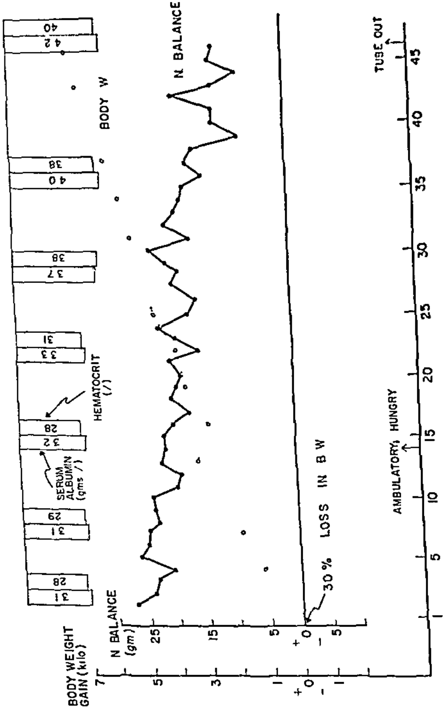

Figure 10 Weight Gain and Nitrogen Balance Response of an Advanced Cancer Patient to Tube Feeding

for themselves and hence were happier and less of a nursing problem Many who were bedfast in the hospital were temporarily restored to family living without special care It was not possible to determine whether length of life was extended or shortened in these patients, just as it is difficult to predict the duration of life in most patients dying of cancer Tumors that were palpable or visible seemed to increase in size pari passu with gain in body weight

None of the patients studied failed to show a positive nitrogen balance beginning with the onset of feeding The cancer patients showed positive nitrogen balances to the same degree as did non cancer patients in similar stages of depletion (Table 8)

The rates of weight gain together with nitrogen balance data are recorded in Table 8 A typical response is depicted in Figure 10 The expected (theoretical) weight gain may be calculated from the nitrogen balance figures (theoretical weight gain = gm N retained X 6 25 X 5) In Table 8 this calculation is employed in establishing a ration between theoretical and actual weight gain No significant difference can be noted between those with and those without cancer

The changes in serum albumin and hemoglobin concentrations are shown in Table 9 As expected from the observations of others, there was a greater increase in hemoglobin than in serum albumin concentration this was noted in both cancer and non cancer patients This rise in hemoglobin was essentially the same in the cancer and non cancer groups The data on serum albumin were somewhat different in that all of the non cancer patients showed some increase in serum albumin concentration, whereas five of the cancer patients showed either a continuing fall or no rise during feeding

That anorexia is largely the cause for the cachexia of advanced cancer was clearly demonstrated in these studies by the uniformity with which appetite returned within one to three weeks after the start of tube feeding That weight gain positive nitrogen balance, and clinical improvement followed in both cancer and non cancer cachexia would seem to indicate that

changes in serum albumin concentration, not on total circulating albumin Other observers, as already mentioned, have also noted an apparent deficiency in serum albumin regeneration in cancer patients (28 29)

These studies demonstrate again that malnutrition itself may beget anorexia and thus perpetuate itself The advanced cancer patients studied were not undernourished because of any specific effects of the cancer but because of anorexia Moreover, the process of progressive malnutrition in these patients can be reversed, and appetite restored, by appropriate tube feeding Tube feeding in patients with advanced cancer seemed neither to lengthen nor shorten life in terms of tumor growth Nevertheless, in the cases selected, the beneficial clinical effect of such feeding was clear, as shown by return of appetite, partial return of strength, and an increased sense of well being This led to a happier situation for family and patient, to decreased demands on nursing service (in hospital or home), and to the feasibility of hospital discharge in a significant number of advanced cancer patients who had been bedridden because of profound asthenia owing to starvation

there is no fundamental impairment in anabolism in patients with widespread cancer, findings that confirm the data of others (27-30) The only difference observed was in the regeneration of serum albumin All of the patients with non-cancer cachexia showed some degree of restoration in serum albumin concentration, whereas five of fourteeen patients with cancer cachexia showed either no increase or a continued fall in serum albumin in spite of significant increases in hemoglobin concentration The other cancer patients showed roughly the same gain in serum albumin as the non-cancer patients This evidence regarding differences in serum albumin regeneration is based only on

TABLE 9

PATIENT	CANCER	DAYS OF TUBE FEEDING	INCREASE IN SERUM ALBUMIN GM/100 ML	INCREASE IN HEMOGLOBIN GM/100 ML
L C	+	49	0 5	2 4
J O	+	49	1 1	3 0
B C	+	30	1 6	1 5
E.S	+	16	1 0	3 7
B G	+	17	-0 6	2 3
N B	+	30	1 1	3 0
E H	+	37	0 3	1 6
L.B	+	27	-0.5	2 0
V C	+	7	0 4	0 5
E H	+	18	0 4	0
O W	+	21	0 5	0
N Y	+	9	0	0 7
F C	+	26	0	1 0
M W	+	25	0	0 5
W.B	–	22	0 8	3 0
W S	–	33	1 0	1 7
S S	–	29	1 1	0
G R.	–	14	0 7	1 0
C S	–	30	0 4	1 0
B S	–	12	0 2	1 0
M.S	–	23	1 1	3 0

Table 9 Serum Albumin and Hemoglobin Regeneration in Malnourished Patients with Advanced Cancer

changes in serum albumin concentration, not on total circulating albumin Other observers, as already mentioned, have also noted an apparent deficiency in serum albumin regeneration in cancer patients (28 29)

These studies demonstrate again that malnutrition itself may beget anorexia and thus perpetuate itself The advanced cancer patients studied were not undernourished because of any specific effects of the cancer but because of anorexia Moreover, the process of progressive malnutrition in these patients can be reversed, and appetite restored, by appropriate tube feeding Tube feeding in patients with advanced cancer seemed neither to lengthen nor shorten life in terms of tumor growth Nevertheless, in the cases selected, the beneficial clinical effect of such feeding was clear, as shown by return of appetite, partial return of strength, and an increased sense of well being This led to a happier situation for family and patient, to decreased demands on nursing service (in hospital or home), and to the feasibility of hospital discharge in a significant number of advanced cancer patients who had been bedridden because of profound asthenia owing to starvation

VII. Some Applications of Tube Feeding in Clinical Surgery

Pre- and Postoperative Applications

Some patients come to surgery in a nutritionally depleted state. A classical example is the patient who has had prolonged, partial pyloric obstruction from duodenal ulcer before definitive therapy is undertaken. Studely stated that the surgical mortality in patients operated upon electively for peptic ulcer was 5% among patients who had lost 20% or less of their body weight, whereas it was 30% in those who had lost more than 20% of their initial body weight (31).

There is a popular concept that undernutrition enhances surgical mortality. This is a very difficult concept to quantitate in the human. Controlled observations are impossible inasmuch as the end point is mortality. Controlled experiments in the albino rat demonstrated that surgical mortality was not enhanced in the acutely starved and chronically undernourished animal (3), but was enhanced by 27% in the animal subjected to protein malnutrition (4).

By virtue of either the nature of the disease, or the urgency of the situation some malnourished patients must be operated upon before nutritional rehabilitation can be instituted. It is especially important in such patients that as intensive feeding as possible be begun as soon as feasible after operation. Even in normally nourished patients Mulholland *et al* (32) has observed that jejunal alimentation begun immediately after gastric resection alleviated postoperative asthenia almost completely and accelerated convalescence. Patients who must be operated upon in the presence of significant malnutrition may, even though the primary disease is eradicated, remain nutritionally crippled for quite long periods post operatively due to the anorexia of malnutrition. Figure 8 depicts events after

institution of tube feeding in a malnourished patient several months after abolition of the primary surgical disease In a matter of seven days after tube feeding was begun the patient was markedly improved and, in thirty days, he was approaching normal nutrition

When circumstances permit, severely malnourished patients should be prepared for operation by tube feeding Figure 11 is a weight gain chart in the case of a seventy two year old man who had lost 40% of initial body weight following proximal gastrectomy and antro esophagostomy with subsequent external fistula formation Figure 12 shows the weight curve and nitrogen balance in a severely malnourished patient with a pancreatic pseudocyst and recurring pancreatitis After three weeks of tube feeding the patient was considerably improved and anorexia abolished Three weeks later, during which time he ate well at home, he was operated upon

Maxillofacial and Oropharyngeal Disease

A very valuable application of tube feeding is in maxillofacial diseases and injuries A most common situation is one in which there is mechanical impediment to chewing but not to the swallowing of liquids What too often happens in such situations is that the patient is given inadequate advice in respect to a wholesome diet and undernutrition ensues For a liquid diet to be adequate it must be concentrated and balanced in respect to its nutritional components This is especially true if the volume taken must be limited The feeding mixture we have been using is ideal in that it constitutes a balanced diet and may be given in concentrated form

A common maxillofacial injury is fracture of the mandible necessitating interdental wiring This situation makes a liquid diet mandatory A very usual occurrence is for these patients to take a grossly inadequate diet and in consequence to lose weight and to become asthenic anorectic and unable to work Since anorexia is so often seen in this situation it must be assumed that the chronic undernutrition is so marked as to approach acute starvation When such patients are tube fed for relatively

TABLE 10

PATIENT	DAYS AFTER JAWS WIRED	WEIGHT LOSS (KILO)	DAYS IN TUBATED	DAYS AFTER ONSET TUBE FEEDING WORK RESUMED	WEIGHT GAIN, END OF TUBE FEEDING (KILO)	HEMOGLOBIN REGENERATION (GMS)
H A	30	6 8	26	7	3 6	2 5
G M	30	4 5	28	21	3 6	3 5
E C	14	5 4	27	14	2 3	1 0
M M	42	4 5	30	7	5 7	1 5
B P	5	1 8	30	7	3 6	2 0
M R	8	2 0	21	4	5 1	2 0
F M	8	2 5	35	8	6 5	1 0
J P	28	5 0	28	14	5 3	1 5

Table 10 Repletion of Undernourished Patients with Fracture of the Mandible and Interdental Wiring while on Tube Feeding

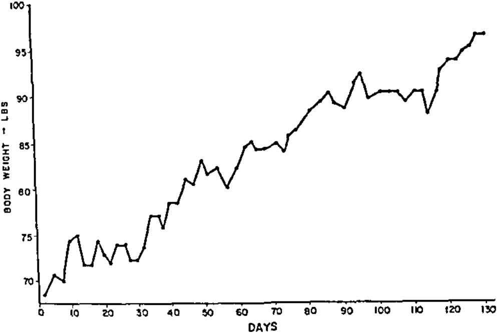

Figure 11 Weight Curve of Severely Malnourished Patient on Tube Feeding During Preoperative Preparation

short periods of time all of these untoward features are reversed Table 10 demonstrates these occurrences in 8 patients and Figure 13 graphically illustrates the typical details in one patient

When intubation is resorted to immediately after repair of these fractures and intermittent tube feeding is practiced on an intermittent basis throughout the duration of dental wiring, no

TABLE 11

PATIENT	DAYS INTUBATED	WEIGHT GAIN (KILO)	LOSS OF STRENGTH	LOSS OF APPETITE
J W	49	6 4	0	0
R D	42	3 9	0	0
H W	28	1 8	0	0
E F	29	2 1	0	0
W M	10	1 4	0	0

Table 11 Tube Feeding from Onset of Interdental Wiring in Patients with Fracture of the Mandible

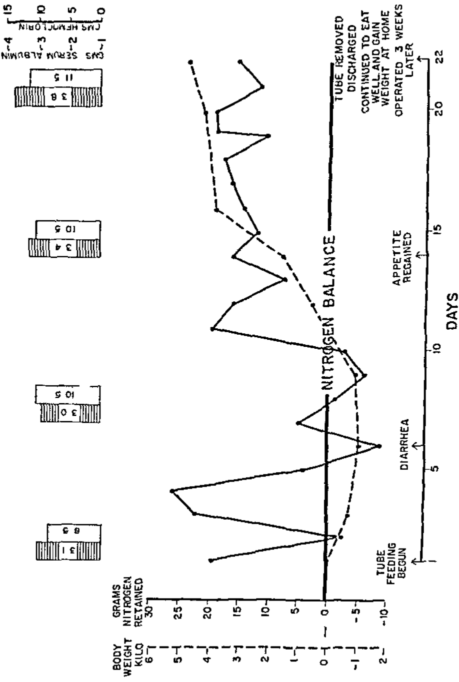

Figure 12 Weight Curve and Nitrogen Balance of a Malnourished Patient Being Prepared for Operation with Tube Feeding

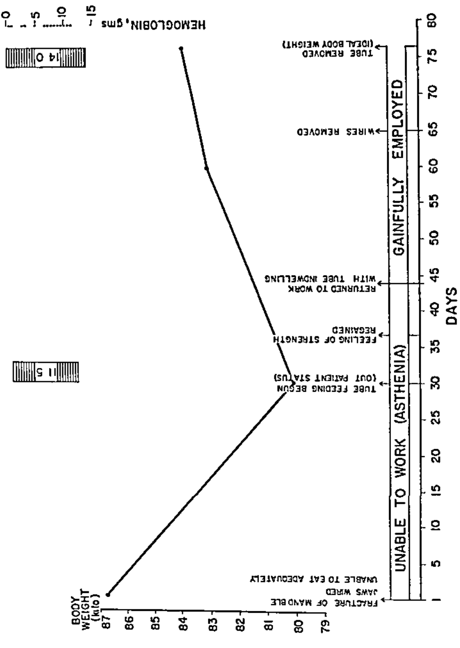

Figure 13 Weight Curve in a Patient with Mandibular Fracture Before and After Employment of Tube Feeding

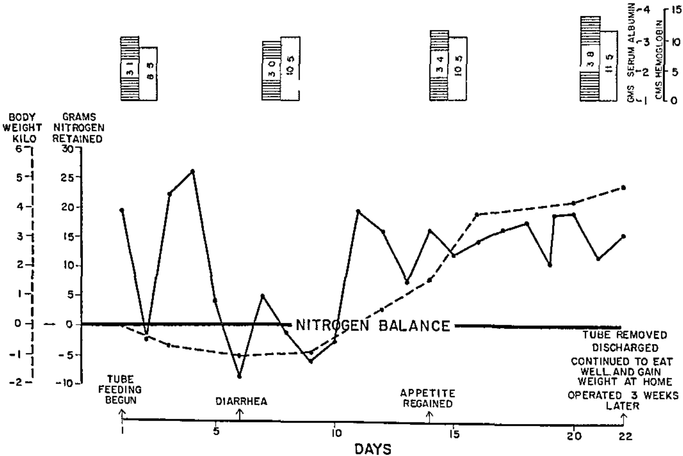

Figure 12 Weight Curve and Nitrogen Balance of a Malnourished Patient Being Prepared for Operation with Tube Feeding

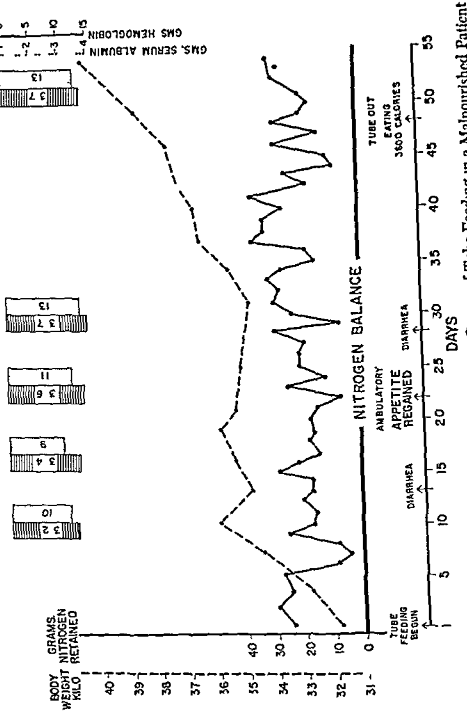

Figure 14 Weight Curve and Nitrogen Balance During Course of Tube Feeding in a Malnourished Patient Following Radiation of Pharyngeal Carcinoma

asthenia, anorexia or weight loss establish (Table 11) These patients remained gainfully employed and carried their liquid feeding to their place of occupation in a thermos container It would seem logical that the same favorable results could be achieved if adequate amounts of the same feeding mixture were drunk from the beginning (before, of course, the appearance of anorexia) Such, indeed, is the case as may be seen in Table 12

Tube feeding, in addition to being invaluable in maxillo facial disease and injury, plays an equally important role in various oropharyngeal diseases Figure 14 presents nitrogen balance and the weight curve in a patient who had become severely undernourished due to ingestional difficulties following deep x ray therapy for carcinoma of the pharynx

Trans Anastomotic Tube Feeding Following Gastric Surgery

Not too infrequently there occur complications of gastro enterostomy which seriously interfere with the nutrition of patients in the postoperative period The magnitude of the nutritional embarrassment is usually maximum irrespective of the complication Oral ingestion of food is just as completely abolished by simple gastric atony as by duodenal stump dehiscence, the degree of nutritional impairment relating only to the duration of the particular complication It seems logical to prepare patients for early tube feeding at the time of gastro-

TABLE 12

PATIENT	DAYS JAWS WIRED AND ON LIQUID FEEDING	WEIGHT GAIN (KILO)	LOSS OF STRENGTH	LOSS OF APPETITE
J W	32	3 0	0	0
E T	31	3 8	0	0
C T	32	0 6	0	0
O M	34	1 0	0	0
L W	18	0 9	0	0

Table 12 Oral Ingestion of Hyperalimentation Mixture from Onset of Interdental Wiring in Fracture of the Mandible

When suturing of the posterior layers of the gastro anastomosis is completed, the polyethylene tube is recovered from the interior of the stomach, drawn an extra foot through the open stoma, and threaded for that distance distally into the efferent enteral loop The polyethylene tube traverses one of three pathways In gastric resection with Billroth II reconstruction, the tube is placed in the nasogastrojejunal route (Figure 15), whereas with Billroth I reconstruction, the tube follows the nasogastroduodenal course (Figure 16) In most cases of simple gastrojejunostomy accompanying vagotomy, a gastrostomy is created using a Foley catheter In these instances the polyethylene tube is placed through the catheter so as to be gastrojejunal in position (Figure 17)

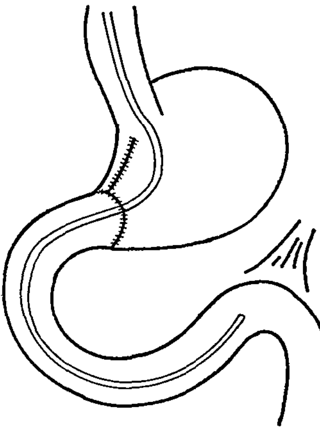

Figure 16 Nasogastroduodenal Placement of Feeding Tube Following Gastric Resection and Billroth I Reconstruction

anastomosis by guiding a fine polyethylene tube, indwelling in the stomach, through the stoma and into the efferent enteral loop at the time of performing open anastomosis If it were found to possess no inherent disadvantages, such a tube could be left in situ, a prophylactic device, until it was evident that no complications ensued and oral ingestion was feasible Should, for any reason, oral ingestion be delayed, this already existent enterostomy could be immediately employed In long term complications the enterostomy would, of course, be critical in recovery of the patient In shorter term complications the enterostomy would serve to maintain a better nutritional status than could otherwise be achieved, and to circumvent, in whole or in part, the ordeal of prolonged parenteral alimentation

Thirty-one patients had polyethylene feeding tubes placed through a gastro anastomosis into the efferent enteral limb at the time of surgery (33) In sixteen patients the tube was used for feeding for varying periods of time In fifteen patients the tube served only a prophylactic purpose inasmuch as feeding was not resorted to, and the tubes were removed when oral ingestion was established A No 15 polyethylene tubing was used in four and one half foot lengths

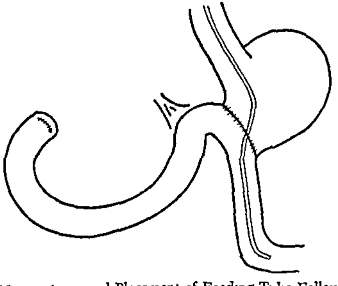

Figure 15 Nasogastrojejunal Placement of Feeding Tube Following Gastric Resection and Billroth II Reconstuction

then cut free from the polyethylene tube outside of the nares, and re-passed under anesthesia

Feeding is not begun until ileus has subsided by at least auscultatory evidence Feedings should be begun in a concentration of half that usually recommended (450 gms added to 2 liters of water, yielding 1,755 calories) and increased over a period of two to three days, or in accord with the patient s tolerance, to full concentration (900 gms added to 2 liters of water, yielding 3,510 calories) At the outset of feeding, the solution is given by continuous drip at a completely even rate of 50 ml per hour and gradually increased, corresponding to the gradual increase in concentration, to 100 ml per hour Periodic aspirations of an indwelling Levine (or Foley gastrostomy) tube should be made to determine the presence of a gastric, or a gastric pouch, residual

No complications could be ascribed to the use of the long feeding tube in any of our cases There was no diarrhoea as the result of feeding and patients experienced nothing unfavorable from its employment The tubes were quite easily placed and easy to care for, and in no sense imposed a burden upon those caring for the patient Regurgitation of the feeding mixture into the stomach or gastric pouch occasionally occurred, but when it did, was very small in amount Feeding was instituted in sixteen of the thirty-one patients while in fifteen feeding was not employed, the tube being removed when the seeming possibility of complications was past and oral ingestion was successfully established In the latter cases the tube was in place for an average time of 6 7 days, the range being three to thirteen days

In the sixteen patients who were fed via the tube, the range of feeding was two to twenty two days Whether used for a short or long period of time, in practically all instances this feeding replaced the need for parenteral alimentation after the first day Some type of complication occurred in four cases of this group, and in these cases the durations of feeding were seven eighteen eighteen and twenty two days In one of these patients, for safety, the tube was kept in place for forty days

The polyethylene tube is brought to the stoma, prior to its recovery and passage into the efferent enteral loop, by one of three means The most common of these is to pass the tube through the nasopharynx and have it swallowed into the stomach on the day prior to the operation This is always satisfactory when gastric resection is performed as in this instance a large opening is made in the stomach through which search for the fine polyethylene tube is quite easy Another method employed consists of tying the distal tip of the polyethylene tube alongside the distal tip of the Levine tube, which is passed just prior to operation, and cutting the small tube free when the Levine tube is momentarily exteriorized through the stoma When difficulty with these methods is encountered, or when it is decided at the time of anastomosis to use the long feeding tube, the proximal end of the polyethylene tube may be tied to the distal end of the Levine tube which is then withdrawn The Levine tube is

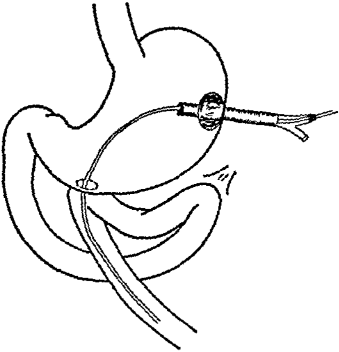

Figure 17 Feeding Tube Placed Through Foley Gastrostomy Tube

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